descriptions. The author has prepared for this contingency by providing references under each genus to the "Flora Australiensis" and the "Flora of New South Wales," and has arranged his system and nomenclature according to the last named. Ferns and fern allies are included, but of monocotyledons the families of rushes, sedges, and grasses are left out.

LETTERS TO THE EDITOR.

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.]*

Magnetic Storm and Aurora on February 9-10.

A MAGNETIC storm was recorded at the Kew Observatory (National Physical Laboratory) on the afternoon of February 9 and early morning of February 10 larger than any that has occurred since October 31, 1903. The curves were slightly disturbed during the whole of February 9, but the storm may be regarded as commencing with a rapid movement of a few minutes of arc in the declination needle at 2.15 p.m., with a synchronous sudden rise of 45 γ (1 γ=0·00001 C.G.S.) in the horizontal force. The storm lasted an unusually short time, being practically over by 3 a.m. on February 10, but several large rapid movements were recorded. The largest declination movement occurred between 8.19 p.m. and 8.45 p.m. on February 9. During these twenty-six minutes the needle moved 57′ to the west and then 73′ to the east, the extreme westerly position being reached at 8.34 p.m. The most easterly position during the storm was reached at about 10.55 p.m., when the trace was off the sheet for a few minutes. The range during the storm actually shown on the sheet was 1° 38′. Between 1.13 a.m. and 1.45 a.m. on February 10 the needle moved steadily, without sensible oscillation, to the west, this movement reaching 1°. The rate of movement was practically uniform from 1.13 a.m. to 1.33 a.m., when it accelerated so suddenly that the curve resembles two straight lines inclined at a finite angle.

In the case of the horizontal force, the force fell more than 355 γ between 8.25 p.m. and 8.33 p.m. on February 9, when it went off the sheet for a few minutes. Between 8.40 p.m. and 8.49 p.m. it increased fully 240 γ. The total range during the storm exceeded 480 γ.

The vertical force, though less disturbed than the other elements, showed a range of 325 γ, the highest and lowest values being attained at 6.25 p.m. on February 9 and 1.48 a.m. on February 10 respectively. The most rapid change took place between 8.25 p.m. and 8.42 p.m. on February 9. The storm was doubtless associated with the aurora, which seems to have been widely observed on the evening of February 9.

CHARLES CHREE.

AN unusually beautiful display of aurora borealis was seen here (51° 56′ N. lat., 2° 35′ W. long.) between 6.30 p.m. and 11 p.m. on Saturday evening, February 9. At about 6.30 p.m. I became aware that the north-western sky, instead of darkening after sunset, was becoming lighter, and the quivering upward rays showed that it was the northern lights. The aurora was at its best between 8 p.m. and 9.30 p.m., stretching half across the northern heavens from Cetus to Leo, from the horizon upwards towards the zenith, some of the curved flashes reaching to Jupiter.

This aurora was characterised by the brilliant soft whiteness of its light, occasionally tinged with pale green, which filled the north-western and northern sky from the horizon to a considerable elevation, from which at times long rays shot up; but more generally the lights appeared as curved, wavy bands rushing up to the zenith, and hanging there for a few seconds as white, cloudy patches in the clear sky among the brighter stars. Between 8.45 p.m. and 9.15 p.m. the colour about Ursa Major and Leo was a dull, faint red. The aurora was not watched after 11 o'clock, but by that time it had greatly diminished in brilliancy, and the sky was becoming cloudy.

I may add that for some weeks I have been noting the sun-spots, of which lately there have been a considerable number, and on the morning of February 9 one near the middle of the sun's disc was so large that I afterwards saw it with the naked eye through smoked glass.

E. A.

Dadnor, near Ross, Herefordshire, February 11.

The Flight of an Elongated Shot.

WOULD any reader of NATURE kindly enlighten me on the following points in the theory of projectiles?

(1) Whether one is right in supposing that a bullet or shot of the modern pointed cylindrical form, when fired at any angle of elevation *in vacuo*, would preserve the original direction of its axis of rotation, so that at the end of its flight its long axis would be considerably inclined to its line of flight.

(2) Whether a similar shot fired through the air would be acted upon by a couple tending to produce rotation about an axis perpendicular to the plane of the trajectory, the magnitude and direction of this couple depending upon the form of the projectile and the position of its centre of gravity, a zero value being possible; and whether the effect of this couple would be to produce rotation about an axis in the plane of the trajectory and perpendicular to the long axis of the shot, so that the point of the projectile would be deflected downwards and to the right or left.

(3) Whether, if the above suppositions are correct, any successful attempts have been made to keep the long axis of the shot tangential to its trajectory during the whole course of its flight, by giving it a particular form, and varying the density of its parts in a particular way.

P. D. STRACHAN.

Philippolis, Orange River Colony.

THE answer to proposition (1) is best given for the most general case. A body projected in any manner in a field of gravity *in vacuo* will move so that the centre of gravity (C.G.) describes a parabola, while the body moves about the C.G. so that to an observer seated at the C.G. the body has the motion described by Poinsot, in which the momental ellipsoid rolls on a fixed plane. The normal to this plane is the axis of resultant angular momentum, and this axis preserves a direction fixed in space, while the body moves about it. When this axis coincides with a principal axis, the body appears to be spinning steadily about the axis, but a closer observation reveals always a precessional and nutational motion.

The question in the limited form of proposition (1) presupposes a body of perfect uniaxial symmetry spun accurately about its axis; but such a condition cannot be realised in practice any more than it is possible to balance a pin on its point, and so it is better to replace this ideal state of proposition (1) by the penultimate state, in which the spinning body, like a sleeping top upright, has steadiness almost perfect.

With this limitation the axis of an elongated shot would move parallel to itself, on the whole, if fired in a vacuum as stated in proposition (1). But if fired in air, as in proposition (2), a couple arises as soon as the axis is oblique to the direction of motion, tending to place the axis of an elongated shot broadside to its motion and at right angles to the tangent of the trajectory, and this couple acting on the rotating shot will cause the axis to precess about the tangent. Even in the absence of air resistance and gravity, the resulting motion is of great complexity where the body is influenced by the stirring up of the surrounding medium, and the special case of a figure of revolution, discussed by Kirchhoff and Clebsch, is more complicated than the gyroscopic motion of a top spinning in a smooth cup.

The problem defies analysis when gravity and air resistance are taken into account: all we can say is that the frictional drag damps the nutation, and causes the axis of the shot to follow the tangent of the trajectory very closely, the point of the shot being seen to be slightly above the tangent and to the right, with a right-handed spin. The conditions of proposition (3) are secured then

independently of any supposition or condition of shape and density of the shot, provided the spin imparted by the rifling is suitable, and that the trajectory is not curved too much. A. G. GREENHILL.

The Atomic Weight of Nickel.

IN a paper on the absorption of Röntgen rays (*Journal de Physique*, p. 653, 1901) M. Benoist shows the connection between the transparency to X-rays of elementary substances and the atomic weight of those substances by means of a curve, which in general exhibits a fall of transparency with a rise in the atomic weight of the absorbing substance. In continuing investigations on secondary X-rays, Mr. C. A. Sadler and I have found that by replacing Benoist's primary beam by secondary beams from different substances, curves are obtained similar to that got by using a beam direct from an X-ray tube, except in the region of atomic weights near to that of the radiator. In those regions a strongly marked deviation occurs, showing a special transparency to the secondary radiation from a substance, by a sheet of the same substance, and a less strongly marked abnormal transparency of those substances with atomic weights differing little from that of the radiator. Also the nearer on the same side the atomic weight of the absorbing substance is to that of the radiator, the greater is the deviation from the normal transparency. This effect does not indicate that the secondary rays as emitted by the atoms of a substance are specially penetrating, but simply that in emerging from the interior atoms to the surface a selective absorption has occurred, leaving the remainder specially penetrating to further layers of the same substance and to a less extent to substances of neighbouring atomic weights. This is not a property of secondary rays alone, for experiments on primary beams which have passed through thin sheets of metal show the same effect.

In making such experiments on a number of metals it was found that the radiation from nickel was much more abnormally penetrating to copper than to iron, indicating a proximity of atomic weight to that of copper. On the other hand, when cobalt was used as a radiator the rays were much more abnormally penetrating to iron than to copper, indicating that the atomic weight of cobalt is nearer that of iron than of copper.

The two experiments together furnish what seems to us to be the strongest evidence, based, not only on empirical law, but on theory, that the atomic weight of nickel is not slightly less than that of cobalt (the accepted values are Ni 58·7, Cr 59), but is considerably greater.

The evidence, however, does not end here. In a paper on secondary Röntgen radiation I suggested a method of determining atomic weights—based on the fact that the radiation is purely an atomic property—by graphically plotting the absorbability of the secondary radiation proceeding from different elements subject to X-rays and the atomic weight of the radiator. A periodic curve was obtained in many portions of which the slope was so great that atomic weights might be obtained by interpolation with considerable accuracy.

Using a thin plate of aluminium as the absorber, the relation between the absorbability of the radiation and the atomic weight of the radiator was found to be approximately a linear one for a long range of atomic weights on both sides of nickel. Nickel itself, however, can only be brought into line by assigning it an atomic weight a little above 61. Many absorbing substances have been used, and all give approximately the same value, the maximum variation in the values found from these different experiments being about 0·3.

The experiments on fairly good commercial specimens indicated an atomic weight of about 61·4. To make the evidence more conclusive and the numerical values as accurate as possible—though a 2 per cent. or 3 per cent. impurity could not materially affect the result—the purest specimens were used, and the atomic weight found by two separate series of observations did not differ by more than about 0·1 from the value previously obtained. We are thus forced to the conclusion that the atomic weight of nickel is about 61·3. Details of these experiments we hope to publish shortly. CHARLES G. BARKLA.

University of Liverpool, February 6.

ON HOMER LANE'S PROBLEM OF A SPHERICAL GASEOUS NEBULA.

§ 1. A HIGHLY interesting problem of pure mathematics was brought before the world in the *American Journal of Science*, July, 1870, by the late Mr. Homer Lane, who, as we are told by Mr. T. J. J. See,[1] was for many years connected with the U.S. Coast and Geodetic Survey at Washington. Lane's problem is the convective equilibrium, of density, of pressure, and of temperature, in a rotationless spherical mass of gaseous fluid,[2] hot in its central parts, and left to itself in waveless quiescent ether.

§ 2. For the full discussion of this problem we must, according to the evolutionary philosophy of the physics of dead matter, try to solve it for all past and future time. But we may first, after the manner of Fourier, consider the gaseous globe as being at any time given with any arbitrarily assumed distribution of temperature, subject only to the condition that it is uniform throughout every spherical surface concentric with the boundary. And our subject might be the absolutely determinate problem of finding the density and pressure at every point necessary for dynamical equilibrium. But for stability of this equilibrium, Homer Lane assumed, rightly as I believe is now generally admitted, that it must be of the kind which two years later[3] I called convective equilibrium.

§ 3. If the fluid globe were given with any arbitrary distribution of temperature, for example uniform temperature throughout, the cooling, and consequent augmentation of density of the fluid at its boundary, by radiation into space, would immediately give rise to an instability according to which some parts of the outermost portions of the globe would sink, and upward currents would consequently be developed in other portions. In any real fluid, whether gaseous or liquid, or liquid with an atmosphere of vapour around it, this kind of automatic stirring would tend to go on until a condition of approximate equilibrium is reached, in which any portion of the fluid descending or ascending would, by the thermodynamic action involved in change of pressure, always take the temperature corresponding to its level, that is to say, its distance from the centre of the globe.

§ 4. The condition thus reached, when heat is continually being radiated away from the spherical boundary, is not perfect equilibrium. It is only an approximation to equilibrium, in which the temperature and density are each approximately uniform at any one distance from the centre, and vary slowly with time, the variable irregular convective currents being insufficient to cause any considerable deviation of the surfaces of equal density and temperature from sphericity.

§ 5. A very interesting and important theorem was given by Prof. Perry, on p. 252 of NATURE for July, 1899, according to which, for cosmical purposes, it is convenient to divide gases into two species—species P, gases for which the ratio (k) of thermal capacity, pressure constant, to thermal capacity, volume con-

1 "Researches on the Physical Constitution of the Heavenly Bodies" *Astr. Nachr.*, November, 1905.)

2 By a gaseous fluid I here mean what is commonly called a "perfect gas," that is, a gas which fulfils two laws:—(1) Boyle's law. At constant temperature it exerts pressure exactly in proportion to its density, or in inverse proportion to the volume of a given homogeneous mass of it; (2) A given mass of it, kept at constant pressure, has its volume exactly proportional to its temperature, according to the absolute thermodynamic definition of temperature (Preston's "Theory of Heat," Article 290). According to the "Kinetic Theory of Gases," every gas or vapour approximates more and more closely to the fulfilment of these two laws, the smaller is the proportion of the sum of times in collision to the sum of times of moving approximately in straight lines between collisions.

3 "On the Convective Equilibrium of Temperature in the Atmosphere." (Literary and Philosophical Society of Manchester, January 21, 1862; re-published as Appendix E, Math. and Phys. Papers, vol. iii.)